PERIODICAL
V.9.no.11
SHED Norway - Fisk.

FISKERIDIREKTORATETS SKRIFTER
Serie Havundersøkelser
(Report on Norwegian Fishery and Marine Investigations)
Vol. IX. No. 11.
Published by the Director of Fisheries

LIBRARY
FISH & WILDLIFE SERVICE
PACIFIC OCEANIC FISHERY
INVESTIGATIONS
OCT 23 1951

The Norwegian — Icelandic Herring Tagging Experiments

Report No. 1

by

'ARNI FRIDRIKSSON
and
OLAV AASEN

1950

A.s John Griegs Boktrykkeri, Bergen

Report on Norwegian Fishery and Marine Investigations:

Vol. I. (1900)

Out of print.

Vol. II.

Part I.

Nr. 1. Oversikt over Norsk fiskeri- og havforskning 1900—1908. (Review of Norwegian fishery and marine investigations 1900—1908). Pp. 1—204. 1909.

» 2. *B. Helland-Hansen* and *Fridtjof Nansen:* The Norwegian Sea: Its physical oceanography based upon the Norwegian researches 1900—1904. Pp. 1—360 with 3 tables and 28 plates. 1909.

Part II.

» 3. *R. Collett:* Fiske, indsamlede under »Michael Sars«s togter i Nord-havet 1900—1902. Pp. 1—151 med 2 plancher. 1905.

» 4. *J. W. Sandström* und *B. Helland-Hansen:* Ueber die Berechnung von Meeresströmungen. Pp. 1—43. 1903.

» 5. *H. H. Gran:* Das Plankton des Norwegischen Nordmeeres von biologischen und hydrographischen Gesichtspunkten behandelt. Pp. 1—222 mit 1 Tafel. 1902.

» 6. *Knut Dahl:* The scales of the herring as a means of determining age, growth and migretion. Pp. 1—36 with 3 plates. 1907.

Vol. III.

Nr. 1. *Paul Bjerkan:* Age, maturity and quality of North Sea herrings during the years 1910—1913. Pp. 1—119. 1917.

» 2. *Paul Bjerkan:* The young herring of the North Sea. Pp. 1—21. 1918.

» 3. *Alf Dannevig:* Fiskeegg og yngel i Lofoten. Pp. 1—63. 1919.

» 4. *Einar Lea:* Frequency curves in herring investigation. Pp. 1—27. 1924.

» 5. *Oscar Sund:* Merking av sei i Nordland sommeren 1921. Pp. 1—18 med tabeller og 3 plancher. 1925.

» 6. *Alf Dannevig:* On the growth of the cod and the formation of annual zones in the scales. Pp. 1—23 with 13 plates. 1925.

» 7. *Birgithe Ruud:* Quantitative investigation of plankton at Lofoten, March—April, 1922—1924. Pp. 1—29. 1926.

» 8. *H. H. Gran:* The production of plankton in the coastal waters off Bergen, March—April 1922. Pp. 1—74. 1927.

» 9. *Alf Dannevig:* The rearing of lobster larvae at Flødevigen. Pp. 1—15. 1928.

» 10. *Alf Dannevig:* The propagation of our common fishes during the cold winter 1924. Pp. 1—133. 1930.

Vol. IV.

Nr. 1. *Alf Dannevig:* On the Age and Growth of the God (Gadus callarias L.) from the Norwegian Skagerrak Coast. 1933.

» 2. *Einar Lea:* Connected Frequency-Distributions. 1933.

» 3. *Gunnar Rollefsen:* The Otoliths of the Cod. 1933.

» 4. *Alf Dannevig* and *Adolf Sørensen:* On the Age and Growth of the Pollack (Gadus pollachius L.) from the Norwegian Skagerrack Coast. 1933.

» 5. *Thor Iversen:* Noen iakttagelser over fiskeyngel i trålfangster i Barentshavet. 1933.

» 6. *Jens Eggvin:* A Norwegian Fat-Herring Fjord. An Oceanographical Study of the Eidsfjord. 1933.

Nr. 7. Torsken og Fiskehavet 1933. The Cod and Sea in 1933: 1934.
1) Torskebestanden, av Oscar Sund, p. 3.
2) Skreiens alder, av Gunnar Rollefsen, p. 12.
3) Vestfjorden, av Jens Eggvin, p. 15.

» 8. *Thor Iversen:* Some Observations on Cod in Northern Waters. 1934.

» 9. *Jacob D. Sømme:* Animal Plankton of the Norwegian Coast Waters and the open Sea. I. Production of Calanus finmarchicus (Gunner) and Calanus hyperboreus (Krøyer) in the Lofoten Area. 1934.

» 10. *Erling Sivertsen:* Torskens gytning. Med særlig henblikk på den årlige cyklus i generasjonsorganenes tilstand. 1935.

» 11. *Gunnar Rollefsen:* The Spawning Zone in Cod Otoliths and Prognosis of Stock. 1935.

» 12. *Alf Dannevig:* Hummer og Hummerkultur. 1936.

FISKERIDIREKTORATETS SKRIFTER
Serie Havundersøkelser

(Report on Norwegian Fishery and Marine Investigations)
Vol. IX. No. 11.

Published by the Director of Fisheries

The Norwegian — Icelandic Herring Tagging Experiments

Report No. 1

by

'ARNI FRIDRIKSSON

and

OLAV AASEN

1 9 5 0

A.s John Griegs Boktrykkeri, Bergen

Digitized by the Internet Archive
in 2025

https://archive.org/details/fiskeridirektoratets-skrifter-serie-havundersokelser_1951_9_11

CONTENTS

	Page
Preface	5
Introduction	7
Preparatory work	8
Technique and Equipment	9
The Taggings	14
The Returns	20
Conclusion	31

PREFACE.

The present paper is an account of the Norwegian—Icelandic herring taggings and of the results so far obtained. The authors are greatly indebted to the Icelandic Ministry of Fisheries, Reykjavik and Fiskeribedriftens Forskningsfond, Bergen, whose grants have made the work possible. We offer our best thanks to Fishery Supervisor Mr. Håkon Vikse for valuable services rendered, and to the great number of fishermen who readily have supplied the live herring for tagging. Especially we wish to thank the owners and managers of the herring meal factories who, with great expense to themselves, have installed magnet separators in the factories for the recovery of the tags. We also wish to express our thanks to Director Gunnar Rollefsen of Fiskeridirektoratets Havforskningsinstitutt and Fishery Consulent Finn Devold for valuable advice and for their great interest in the tagging work. Thanks are also due to Fishery Consulent Gunnar Dannevig for criticism of the manuscript, and particularly we wish to acknowledge our indebtedness to Dr. William Hodgson for reading over and amending the English text.

Bergen May, 1950.

INTRODUCTION

Tagging of fish is frequently used by the fishery biologist as a means of studying the migrations, and of demonstrating the effect of fishing on a stock of fish. By means of tagging, it is also possible to follow fluctuations in the stock strength and to arrive at an estimate of the size of the fish stock concerned. A thorough knowledge of these questions is of fundamental importance for the rational exploitation of the commercial fishes and also for furnishing the necessary information needed to meet possible threats from overexploitation.

The idea of tagging fish is not a new one, for succesful experiments were carried out in the last century. Tagging on a large scale was first done in the year 1872, but the marking of fish originates from much earlier times. Tagging of salmon was mentioned in »The Compleat Angler« published in 1654.

Regarding the tagging of herring, practical difficulties were encountered, but in spite of that, herring marking was introduced at least as early as in 1892 by the Scottish scientist T. Wemyss Fulton, this marking being done by punching holes in the caudal fin of the herring. He also succeeded in "ticketing" some 600 herring (Fulton 1893, page 191). Fulton's experiments, however, were unsuccessful and no recaptures were reported. Unfortunately, no further attempts to mark herring were made for 30 years and it was generally assumed that herrings were unsuitable for marking. The specific difficulties were supposed to be, firstly, the delicacy of the herring, and secondly, that the marks would easily escape detection owing to the fish being caught in large numbers and the subsequent mass handling in reduction plants etc. Through information furnished by Dr. Erik M. Paulsen of Copenhagen, it appears that the next attempt at herring tagging was made by the Danish scientist A. C. Johansen who made some attempts to mark herring in 1922 using external tags, but his experiments, too, proved unsuccessful. It was Rounsefell and Dahlgren, of America (1933) who first found a solution to the difficulties of herring tagging. The performance of different types of tags was tested by making comparative experiments, and the most suc-

cessful proved to be an internal belly-tag. The recovery of this kind of tag presented certain difficulties, which were eventually overcome by the ingenious method of installing magnets in the reduction plants. This method of tagging has been carried out in the U. S. A. and Canada for quite a number of years with good results, and it has now also been tried out successfully in Europe, as will be seen from the following account.

1. PREPARATORY WORK

When Arni Fridriksson, in 1935, arrived at the conclusion that the herring caught during the summer off the north coast of Iceland (Nordurlandssildin) were, at least, partly identical with the Norwegian winter herring, he found it desirable to carry out some kind of tagging in order to prove or disprove this theory (Fridriksson 1944). It was, however, evident that such experiments could not be successful unless carried out in close co-operation between Icelandic and Norwegian scientists.

Immediately after the World War II, contact was established between the Icelandic and Norwegian authorities, on the initiative of Arni Fridriksson, and the idea of collaboration in a herring tagging scheme was greeted with enthusiasm by the Director of Fisheries in Norway, Mr. Ola Brynjelsen, and Fishery-Consulent Mr. Einar Lea. Consequently a preliminary meeting was arranged in Oslo in May 1947 at which Fridriksson and Lea discussed the matter and formulated a plan for a Norwegian-Icelandic tagging scheme. In a memorandum, dated May 4th 1947, to the Norwegian and Icelandic governments, they recommended the introduction of the American method of herring marking by internal tags, but, owing to special conditions in the Icelandic and Norwegian waters, it was considered necessary to design special equipment for operation in the open sea. It was further recommended that the first tagging experiments should take place in Icelandic waters during the summer of 1947.

Following up this scheme, the authors of this paper met at Siglufjord, Iceland in July 1947 in order to make the necessary preparations and, if possible, to start the work, but owing to unforeseen difficulties, it proved impossible to carry out any marking that summer. On the other hand, some experiments were made in order to gain experience for future work. They were as follows:

a. The efficiency of the separator-magnets in two reduction plants with different types of machinery was tested. These trials were unsuc-

cessful and it became evident that all the magnets in the factories had to be inspected and if necessary amended.

b. The tagging equipment was tried out on dead herring in order to find out the best way of cutting the herring open, and inserting the tag. The results will be given later on when dealing with the technique.

c. Experiments were carried out on 80 marked herring which were kept together with a similar number of untagged herring in a wooden tank on board the patrol ship »M/S »Ægir«. After 36 hours 20 % of the untagged and 25 % of the tagged herrings were dead. Four herrings had shed the tag.

At the close of these experiments a short preliminary report, dated Reykjavik, August 9th 1947, was prepared, containing information about the experience gained and recommendations for the detailed methods for future work.

Following from the results mentioned above under (a), all herring reduction plants which were already equipped with magnets were inspected and any necessary amendments were made. Further provisions were made for furnishing the plants which did not have magnets, with such equipment, but naturally, to do this in all the factories would take some time. The present situation is as follows: On the north coast of Iceland all the factories are now fitted with separator-magnets, the majority of the plants having been already fitted with magnets prior to 1947. On the west coast of Norway 25 factories are now equipped with magnets, only a few of these having had separator-magnets at the beginning of these experiments. There still remains a number of factories which have not yet got magnets, but further efforts are being made to get these also to participate in the scheme.

2. TECHNIQUE AND EQUIPMENT

Tagging of herring has now been carried out during four fishing seasons. Different gears and vessels have been used and in the following section a description will be given of the equipment and methods which are now regarded as being the most suitable under different conditions in Norwegian and Icelandic waters. For a working team of four men (excluding the crew) a boat of say 40—50 feet will be large enough, but when working from land bases, a smaller boat will suffice. This, however, usually means considerable travelling to and from the working place, with a corresponding loss of time. On the other hand, on a small craft

one may work from the deck and this is an advantage. On the larger vessels one cannot work from the deck and a large rowing boat will be required in addition. Any craft with ample working space for four men will do. When operating in the open sea, a motor dory is to be preferred to a rowing boat, for the use that can be made of a hand driven craft, especially in rough weather, is very limited. It may also be required to

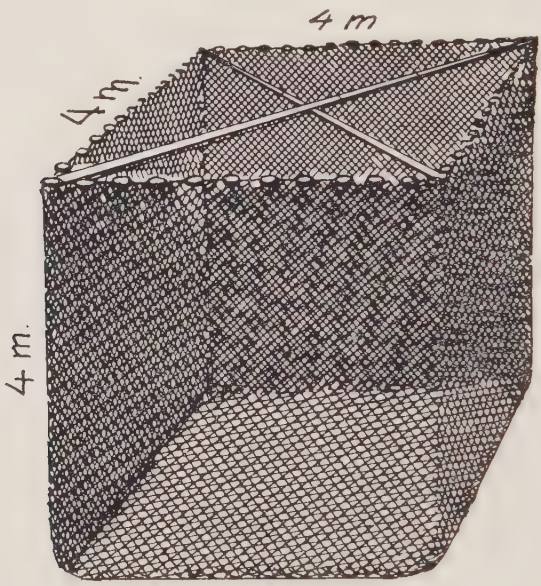

Fig. 1. Net purse for keeping live herring.

tow the purse containing the live herring for some distance into sheltered waters. Such towing operations must be done very carefully, and at slow speeds, which is always difficult with a large vessel. Towing with a rowing boat can only be effected in smooth weather and over very short distances, and furthermore, one may tag whilst towing with the motor driven craft. Transport of live herring in well-boats has turned out to be a failure.

To keep the herring handy for tagging, one may use any equipment which keeps the fish in good condition and within easy reach, and it was found that a "net purse", having small sized mesh, is quite useful. The purse is floated by cork and kept stretched vertically by small pieces of lead in the bottom, and to prevent collapse, wooden bars are placed across the diagonals. The dimensions of the purse are $4 \times 4 \times 4$ metres (Fig. 1). In this purse one can always maintain a convenient concentration of fish, from which one can easely take single herrings, as required, by means

of a dip-net. This is important because experience shows that the dipping of the herring is that part of the operation which requires most time. It is also important that the meshes in the net are small enough to prevent the fish from being damaged and unfit for tagging. A purse is fixed on each side of the boat, one to hold the newly caught fish and the other, to hold the herrings immediately after tagging. (Fig. 2). This arrangement, using a second purse, is employed because experience shows that single herrings when liberated, seem to be lost, and very often even try to join

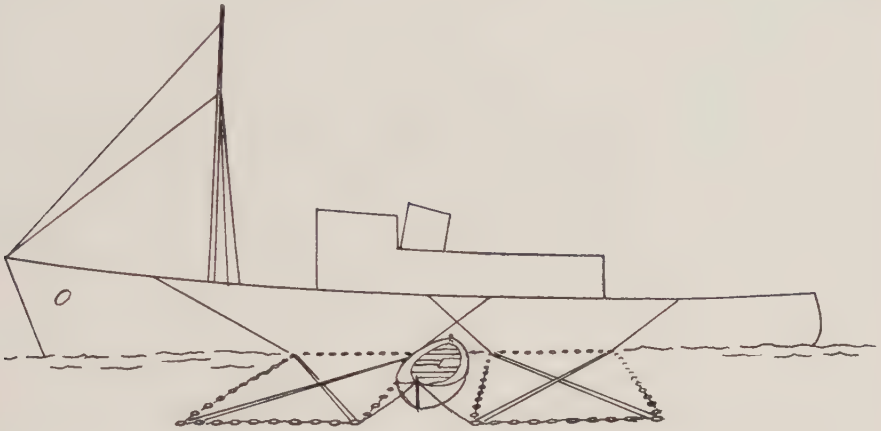

Fig. 2. The arrangement of net purses on either side of the tagging craft.

their comrades in captivity. Once a small shoal is formed in the second purse they behave normally and most often swim away when liberated.

Rough handling of the fish must be avoided when filling the "net purse", and for this reason, only herring caught in land seines or purse seines are used. A good way of treating the herring gently when filling the purse, is to tie together a number of the adjacent floats on the purse, and of the net in which the catch is held, and by submerging these floats, a suitable quantity of fish may be led to swim into the purse. It is of no advantage to pack the purse with herring, for if the fish is not allowed ample space, it easily becomes damaged and has to be thrown away as useless for tagging, and as this is not apparent before the fish is taken up in the dip-net, it often leads to a considerable waste of time. In a purse of the afore-mentioned size, it was found that 10 hl was a convenient amount.

For taking up the herring from the purse, a special type of dip-net — designed after some trials and errors — has proved very useful. In the bottom of this there is a piece of thick cotton cloth. By using cloth instead of net, the pressure of the fish, when held, is evened

out and furthermore the fish is not actually touched by hand. By this procedure one may operate on the herring without undue loss of scales. Between the cloth and the ring of the dip-net there is same ordinary small-meshed net so that the water can flow freely away when the dip net is lifted out of the sea. The net is fastened to a circular ring which moves freely inside another ring mounted on a handle. The point about this rotating dip-net is that one may move the herring into the right position for tagging without touching it — more precisely and quicker than with an ordinary dip-net. The importance of this labour-saving device will be clear from the fact that after its adoption, the work was speeded up by 50 %, and besides, the fish is handled more gently. The dip-net is operated by one man, and here again it pays to take things quietly for, as a general rule, the work goes more quickly when less energy is used in picking up the fish. Furthermore, the fish behaves better when it is not unduly scared.

The herrings are taken up one at the time and, lying in the dip-net, it is moved towards the man who is to hold it in position for tagging. He orientates the dip-net so that the herring is lying with the head towards him and with the ventral side up. He then takes a firm grip with both hands under the dip-net, one hand holding the fore end of the fish and the other the tail end, and between his hands and the fish there is the above-mentioned cotton cloth. By resting his fore-arms on some sort of a table, he can hold the fish very steady.

The next step is to make a small incision through the body wall of the herring. For this purpose a scalpel of a special type as shown in Figure 3 is used. The incision is made at the distal end of the pelvic fin on the right-hand side about two scales from the keel, and one has to remove two or three scales before cutting. This is most easily done with the point of the scalpel. The cut is made parallel to the myomeres so as not to damage the ribs and costal blood vessels. When the herring is in the maturity stages V & VI it seems very difficult to cut without doing damage to the gonads. This, however, is usually not fatal unless considerable quantities of the sexual products are emptied into the body cavity. As investigations of dead tagged herring have shown, this may be a probable cause of death. The scalpel is used by a man sitting just opposite to the man holding the herring.

The tag is inserted into the body cavity by means of forceps of a type shown in Figure 3. These forceps must be thin and flexible so that they follow the tag easily into the wound and with a minimum of pressure from the fingers, otherwise the work will become very tiresome, especially in cold weather, as one has to work without gloves and the fingers easily go numb. The tag itself is a small plate of soft steel with

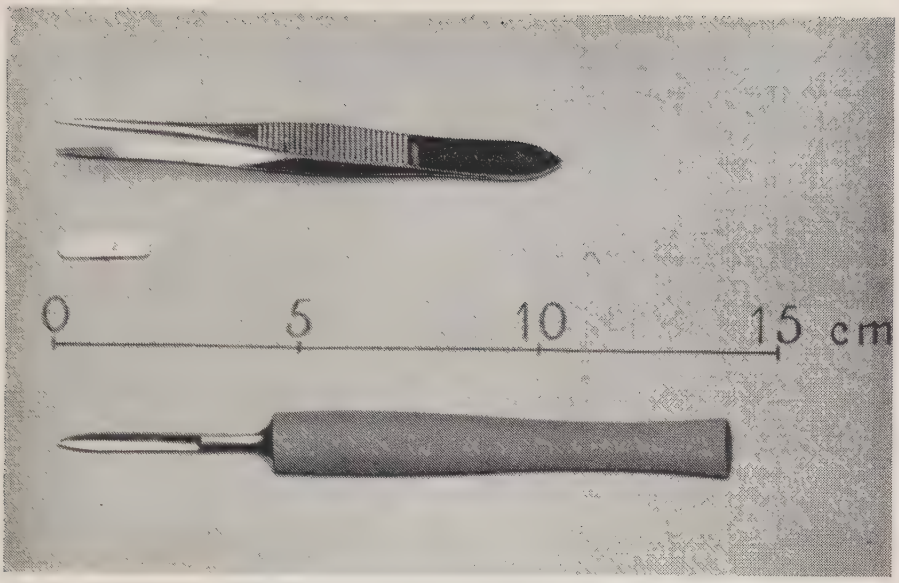

Fig. 3. Forceps, scalpel and tag.

rounded edges and with a serial number stamped on it. In each series there are about 250 tags. The dimensions of the tag are 20 × 3 × 1 millimetres and to prevent it from rusting it may be nickel plated. The tags have to be carefully sorted and counted beforehand. In our routine the series was subdivided in small envelopes with 50 tags in each, and on the envelopes were noted the number of tags and their serial numbers. The empty envelopes are collected and the journal of the day's work may then be made up from them afterwards. The reason why 50 tags per envelope was chosen, is that this seems to be a reasonable quantity to work up at one stretch. Once in a while there must be a break in the work and it is wise to let the men change jobs fairly often. One easily gets cramped and uncomfortable when one has to work in the same position any length of time and cold weather may — and often does — add to the discomfort.

The tags, scalpel, and forceps are disinfected before use. For this purpose a 70 % solution of alcohol and distilled water is used, and it is quite handy to keep the disinfectants in small jars embedded in a solid block of wood to prevent them from sliding about. The contents of one envelope are then emptied into the alcohol when work starts and the tags are picked out, one by one, with the forceps and washed in distilled water before insertion. The tag has to be carefully inserted in from behind and pressed forwards through the wound parallel with the

body to avoid doing damage to vital organs. The forceps are operated by the fourth man in the team. The herring is now tagged and is put into the sea.

The procedure here described may seem complicated but actually the tagging is done much more quickly than the description seems to indicate and with a well trained team the fish is only out of the water for about ten seconds and the whole operation does not seem to effect it much if the above instructions are carried out.

3. THE TAGGINGS

In the following section a survey of the different markings will first be given, each particular cruise being dealt with separately. Then follows a summary of all the experiments with details as to place of liberation, number of tagged fish etc. Lastly, will be set forth some results of the observations made on the behaviour of the herring.

a. *Spring herring tagging in 1948*

The first tagging cruise was carried out with M/S »Armauer Hansen« which was chartered for the purpose from the Geophysical Institute in Bergen. The tagging took place from March 4th to 12th, when the vessel had to be returned to Bergen. The marking team was stationed on board the vessel and the tagging was executed from a life-boat. The live herrings were secured mainly from a land-seine, but purse-seine-caught herrings were also used. The first portion marked was caught by a purse-seiner at night and transferred to the "live" net by dip-nets. The herrings were in a very fine condition and very few had to be rejected as unfit for tagging. The tagged herrings were kept in captivity for a couple of days in order to test the effects of the tagging. The remainder of the herrings tagged this season were secured from a land seine in the vicinity of the first tagging locality.

In the second part of this season's tagging a land base was used. For the transport to and from the tagging place a motor vessel, M/S »Konvallen« was used. A rowing boat was used as the tagging craft.

The weather was favourable during this first season. The fish were abundant and there were no difficulties in securing material.

b. *Tagging of Nordurlandssild in the summer 1948*

A small half-decked boat M/S »Glæsir« was used for the tagging which was intended to start in Siglufjord about July 20th. Owing to

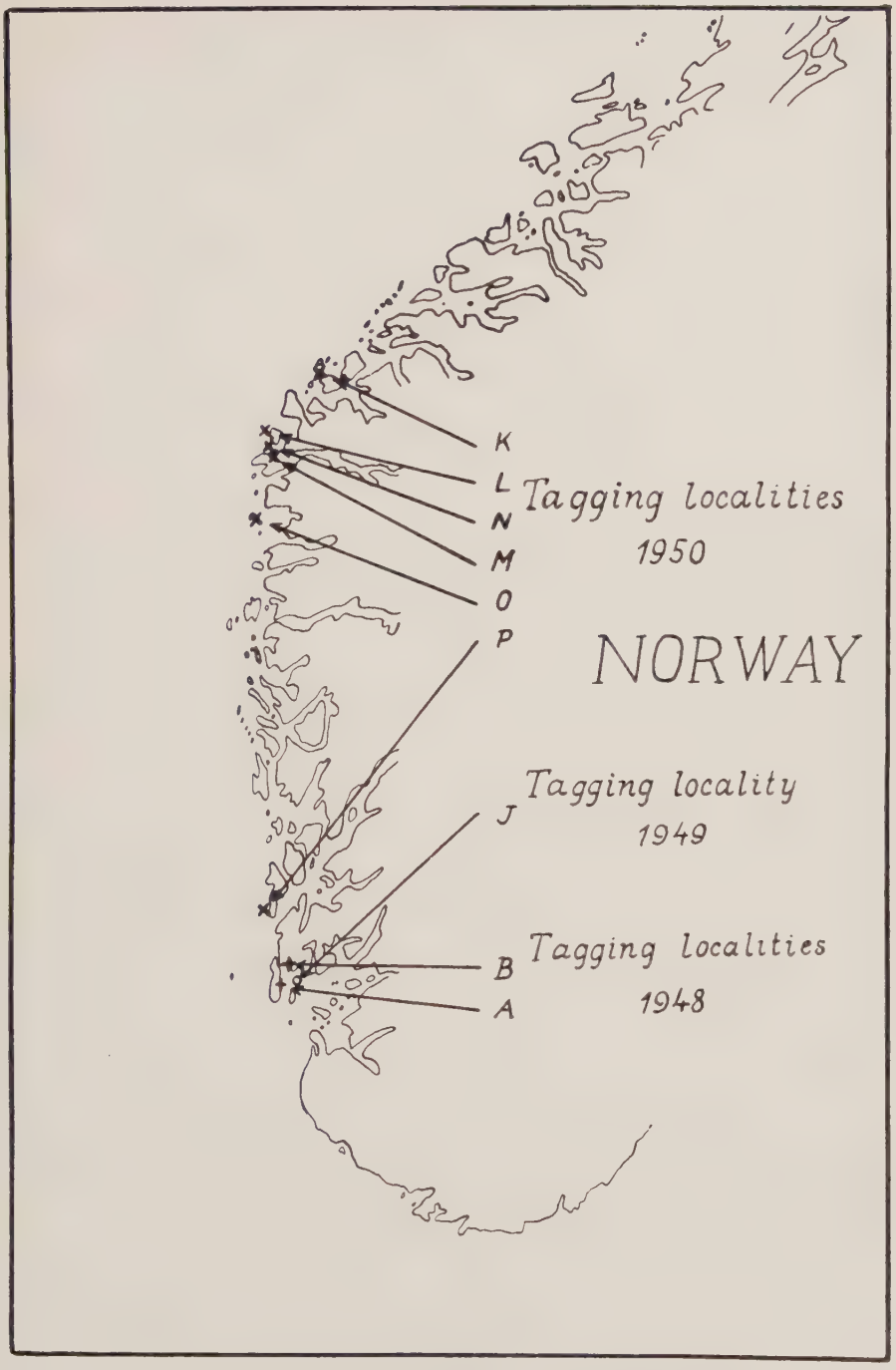

Fig. 4. Tagging localities at the west coast of Norway in 1948, 1949 and 1950.

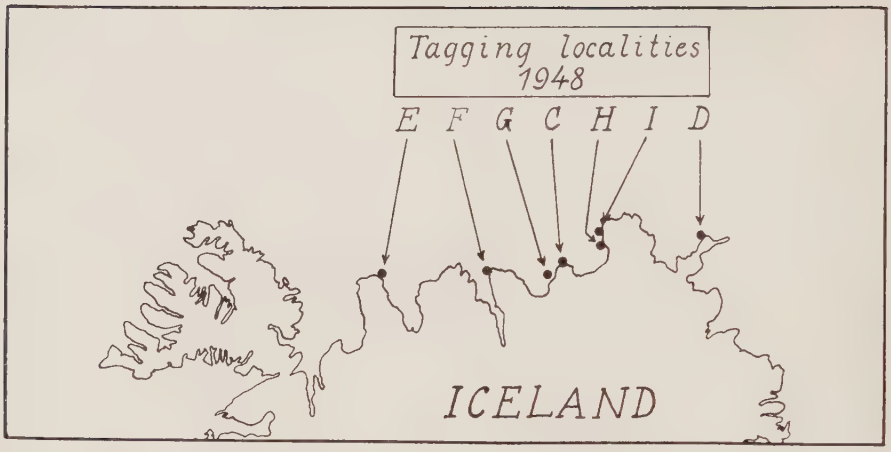

Fig. 5. Tagging localities at the north coast of Iceland 1948.

poor fishing that summer it was difficult to get suitable material for the work. Ony purse-seine caught herring were used, since no land seines are used in Icelandic waters. The tagged herring were liberated at seven different localities.

The weather was not altogether favourable during this second marking cruise, as might be expected when the taggings lasted for five weeks.

c. *Tagging of Spring herring in 1949.*

On this cruise a "commercial traveller" boat M/C »Sundt & Co. II« from Bergen was used. The live herrings were secured from a land-seine and all the marked fish were liberated at the same place. The tagging took place from February 28th to March 10th.

The weather this season was partly rough, but as the tagging took place in sheltered waters this did not hamper the work to any serious extent. Continuous icing during the later part of the season caused some trouble.

d. *Tagging of Large herring in 1950.*

M/C »Johan Hjort« of the Fisheries Directorate of Norway and M/C »Gunnerus« hired from the Biological Station in Trondheim were used for the tagging in the large-herring district. On this cruise we experienced similar difficulties as on the tagging cruise in Icelandic waters. In the beginning of the season the live herrings had to be procured from purse-seiners in the open sea and the weather was at times stormy. On the later part of the cruise land-seine caught herrings were used. The tagged herrings were liberated at five different places.

e. *Spring herring tagging in 1950.*

The same ship was employed as in the previous spring. The tagging was carried out from March 9th to 22nd. Land-seine caught herrings were used and the tagged fish were liberated at the same place. The weather conditions were favourable.

Table 1. *Number of Herrings liberated and Localities of Liberation.*

Year	Date	Place of Liberation	Reference to Fig. 4	Spring-Herrings	Large Herrings	N-Coast-Herrings	Totals	Yearly Totals
1948	6.III	Hestvik	A	1016				
	11—23. »	Breivik	B	5002			6018	
	4.VIII	Tjørnes	C			667		
	8. »	Skoruv.bjarg	D			1412		
	17. »	Skagi	E			927		
	20. »	Gjøgur	F			1205		
	22. »	Lundey	G			769		
	26. »	Leirhøfn	I			1001		
	27. »	Sn.st.nup.	H			1494	7475	13493
1949	28.II—10. III	Trosnavåg	J	8261			8261	8261
1950	1.— 2. II	Vaulen	K		117			
	6.— 9. «	Torskangerp.	L		2494			
	13.—14. »	Fåfjord	M		2250			
	15.—16. »	Vågsvågen	N		2236			
	18.—19. »	Batalden	O		1988		9085	
	10.—22. III	Vespestadv.	P	11215			11215	20300
	Grand Totals:			25494	9085	7475	42054	42054

In Table 1 a summary of the different taggings is given. In column 3 the places of liberation are recorded (see also Figs. 4 & 5). It is worthwhile to note the quite substantial numbers of liberations that have been made, as is apparent from Appendix I. From Table 1 it is evident that three different »categories« of herring (Icelandic north coast herring, Norwegian large herring and Norwegian spring herring) have been dealt with in the experiments (column 4—6). Altogether 25494 Norwegian spring herring have been tagged. The corresponding numbers for Norwegian large herring and Icelandic north coast herring being 9085 and 7475 respectively. The total number of tagged herrings liberated amounts to 42054 (column 7). The yearly totals (column 8) are 13493 in 1948, 8261 in 1949 and 20300 in 1950. Except for the 7475 herrings which were tagged in Icelandic waters in the summer of 1948, all the taggings have been done at the west coast of Norway.

As mentioned in the introduction of this paper it was generally accepted that the herring was too delicate to stand tagging, but according to the experiments made in U. S. A. (Rounsefell and Dahlgren 1933) it became clear that this assumption had to be revised. One of the first tasks was to find out to what extent the tagging operation would effect the vitality of the fish. Consequently, mortality experiments had to be made. As already pointed out the first catch marked was kept in captivity for two days in a land-seine in order to observe the behaviour and general conditions of the herring after tagging. As far as could be seen, the herrings behaved normally after marking. When left quietly in the live-nets both tagged and untagged herrings were swimming constantly in an anticlockwise direction at a speed of about 6—8 meters a minute. When properly picked up and handled the herring showed no signs of panic and during the tagging operation a violent reaction was only noted in exceptional cases. It might happen that a struggling herring lost so many scales that it had to be rejected as unfit for tagging. During the work constant attention was paid to the condition of the fish picked out with the dip-net and only those which were apparently in good condition were selected for tagging. As an indication of the correctness of our judgment of quality it may be mentioned that individuals regarded as unfit for tagging also were placed in the live-nets with the tagged herrings. In some cases dead or dying herrings were observed at the time of liberation. Almost without exception these were found to be untagged fish. This strongly suggested that tagging did not effect the herring to any serious extent, and to clear up this point a further 800 tagged herrings were placed in a land-seine and kept under observation for a fortnight during the first tagging experiment. The result of this was that 6,25 % of the herrings were dead at the end of the experiment. It was, however, evident that some of the herrings had become injured in captivity, and consequently the mortality experiment had to be repeated in order to test properly the effect of tagging. In 1949 such an experiment was carried out but failed to give proper evidence owing to unforeseen difficulties. In 1950 another mortality experiment was attempted. 912 tagged herrings were kept under observation for 13 days in a land-seine together with the same number of untagged herrings, in order to eliminate the effect of captivity. The mortality of the untagged herrings turned out to be 2,30 % (21 fish) and 2,52 % for the tagged herring (23 fish). This difference is not regarded as significant and the conclusion drawn is that properly executed tagging will not effect the vitality of the herring to any considerable extent. It is intended, however, to make further experiments regarding this question.

As indicated on page 5, care should be taken when towing live her-

ring for marking. Experience shows that the damage done to the herring through transport in a careless manner, may largely exceed the effect of marking. The first indication of this phenomenon was observed in Iceland in 1948. The first portion of live herrings for marking was towed in the net purse over a distance of about ½ n. m. in order to reach a suitable place for marking, and about 60 hours later, when the tagged herrings were liberated, 136 (17 %) out of 813 were found to be dead. This high rate of mortality was in marked contrast to the experience earlier in the year in Norway. The question arose as to what extent the herring could stand towing under different conditions. With this experience in mind, we carried out some experiments on different methods of transporting live herring for marking in the large-herring district in 1950. The following summary of the results is interesting:

a. The vessel M/C »Gunnerus«, furnished with a 'live' tank for the transport of fish, was tried for transport of live herring for tagging. This experiment turned out to be a complete failure as 100 % of the fish were unfit for tagging.

b. The usual 'live' net (purse-net) was used for towing herring over distances up to 3 n. m. After this handling, about 10 % of the fish were found suitable for tagging.

c. Live nets were equipped with lead weights (30 kg) and towed at the side of the vessel in order to avoid the current from the propeller. The result was that 18 % of the herring were considered fit for tagging.

d. The live nets were furnished with four floats and four heavy lead weights. The purse squared excellently and this arrangement is regarded as suitable for towing. It was, however, only tried out experimentally without herring.

e. The nets were fastened to the side of a rowing boat which was towed sideways by means of two wires. The squaring of the purse was effected by using weights placed in the bottom front corners. By this procedure 60 % of the herring were fit for tagging after being towed for 1 n.m.

As far as our experience goes, and judging by the above-mentioned results, the transport of live herring for tagging cannot be carried out successfully by using well-boats, at least not those of the »Gunnerus« type. On the other hand the transport of live herring may be successfully accomplished by means of adequately equipped 'live' nets.

Another question of great importance to be settled is to obtain thorough knowledge of the extent to which the herrings are able to shed the tags. From the preliminary experiments mentioned on page 3—4 it was clear that the herring under certain circumstances, could rid itself of the mark. Consequently, shedding tests had to be carried out. Two such

experiments have been made, the first one being in 1948 in the spring herring district, when the shedding percentage was found to be about 1 % after a fortnight from the date of marking (one out of 103 fish examined). The second test took place in the spring of 1950 when 99 herrings were picked out for examination from the fish kept for the mortality experiment. These herrings had been in captivity for 13 days. It is worth noting that in this case, no shedding of tags had taken place and we incline to the view that the shedding of tags is quite insignificant when the taggings are properly executed. However, further experiments on a large scale are needed and will be carried out at the first opportunity.

4. THE RETURNS

The greatest part of the herring catches in Norway and Iceland is reduced to oil and meal. Thus in 1948 77,7 % of the herring caught in Iceland went to the reduction plants, the corresponding portion in 1949 being 83,0 %. The remainder of the yield was cured, or frozen for bait. In Norway, as an average for the last three seasons, 73,7 % of the catches have been reduced to oil and meal, the remainder being mainly exported fresh, cured or used for bait. Furthermore it must be pointed out that in Iceland almost the entire quantity is taken by purse seiners. In Norway the catch taken by seines amounts to 56,7 % (average for the last three years), the rest being caught by driftnets and bottom-nets. Owing to the methods employed in catching the herring and the subsequent treatment of the catches, one must consider about 25 % of the tags in recaught tagged herrings to belost. On the other hand, by using any kind of current external tags, only a minor part of the tagged recaptured herrings would have a proper chance to be detected. As will be mentioned later, 149 tags are now on records, only four of them originating from other sources than reduction plants. (Two of the latter dags were found in herrings being prepared for cooking, the other two in herrings being cut for bait). From these facts the internal tag is considered to be the best one to use in these fisheries. However, it is equally clear that it can only be used with success in countries having a highly developed herring industry. Regarding the number of returns, these cannot as yet be considered from a quantitative point of view as the process of equipping the factories with magnets has been in progress during the tagging work.

In order to secure a constant look-out for tags, the workers in the

factories have been fully informed of the procedure of tagging, and of the importance of furnishing every discovered tag with proper information about date and locality of the catch from which the tag originates. In Appendix II is given a complete survey of all the tags which have been returned up to now. Unfortunately, it was not possible to secure, in all instances, information about the time and place of fishing. In such cases reference is only made to the factory concerned. This applies especially to the recoveries made in Iceland, as will be seen from the Appendix.

Table 2. *Duration of Liberty.*

Number of days at Liberty	NUMBER OF TAGS RETURNED					
	1st. Exp.	2nd. Exp.	3rd. Exp.	4th. Exp.	5th. Exp.	Total
0— 30	4	21	3		7	35
31— 60						
61— 90						
91—120						
121—150						
151 - 180		1				1
181—210						
211—240						
241—270						
271—300						
301—330			3			3
331—360	2	12	11			25
361—390	1	15	18			34
391—420		4				4
421—450				No returns		
451—480						
481—510						
511—540	1	3				4
541—570		5				5
571—600		3				3
601—630						
631—660						
661—690	3					3
691—720	7					7
721—750	7					7
Totals	25	64	35		7	131

In Appendix II, last column, the number of days during which the recaptured tagged herrings were at libery is also recorded. A more surveyable representation of this feature is given in Table 2, in which the

time at liberty is graduated into periods of 30 days (1st. column). The number of tags returned from the different experiments is entered in the following columns (2nd. to 6th) and the totals in the last one (7th). As will be seen, the grand total is different from the figure alrealy mentioned and which appears in Table 3. This is due to the fact stated above that some of the returns are undated and had to be omitted. The groupings of the returns, according to the time scale (1st. and 7th column), are effected through the sharply limited fishing seasons: the winter herring fishery in Norway (January—March) and the summer herring fishery on the north coast of Iceland (July—September). A glance at the figures in the last column will show that about 25 % of the recaptures have been made within 30 days, that is to say, during the marking season. After that there are no possibilities of recaptures before the next season, which takes place one year later in the same country and half a year later in the other one. Already the fact that the groupings in the figures show a half yearly sequence, indicates transoceanic migrations between the stocks. This will be dealt with later on. Table 2 shows further that quite a number of tags has been returned two years after liberation. This may be taken as a proof of the vitality of the tagged herrings, and as an indirect verification of the correctness of the earlier mentioned mortality experiments. As the taggings have only been carried out over a period of two years, it is as yet too early to say for how long after marking the herring will appear in the catches. In Fig. 9 a diagrammatic representation of Table 2 is given, the black columns representing the transoceanic returns. The half yearly sequence in the recoveries is clearly demonstrated.

Another important feature can be extracted by a closer examination from the table. It appears that a batch of tagged herring liberated at the time as a small shoal has given returns on widely distributed localities and scattered over a large period of time. This is a feature of considerable biological interest as it seems to indicate that a shoal of herring will not be permanently maintained as such, but must be considered as a more or less temporary formation. It will be evident from the liberations made at Iceland 1948, where the catches are made almost exclusively by purse-seine, that a bunch of tagged herring, representing only a very small shoal on liberation, must either have been joined by other elements to form a catchable shoal of herring or must have been absorbed by a larger unit. As an example of this the liberation made at Iceland (locality G Fig. 5) from which 15 returns have been recorded, can be noted. The first 3 are recaptures at Iceland during the same season, one tag being returned from Raufarhöfn on August 30th, the next from the same plant on September 4th and the third one from Siglufjord at the end of

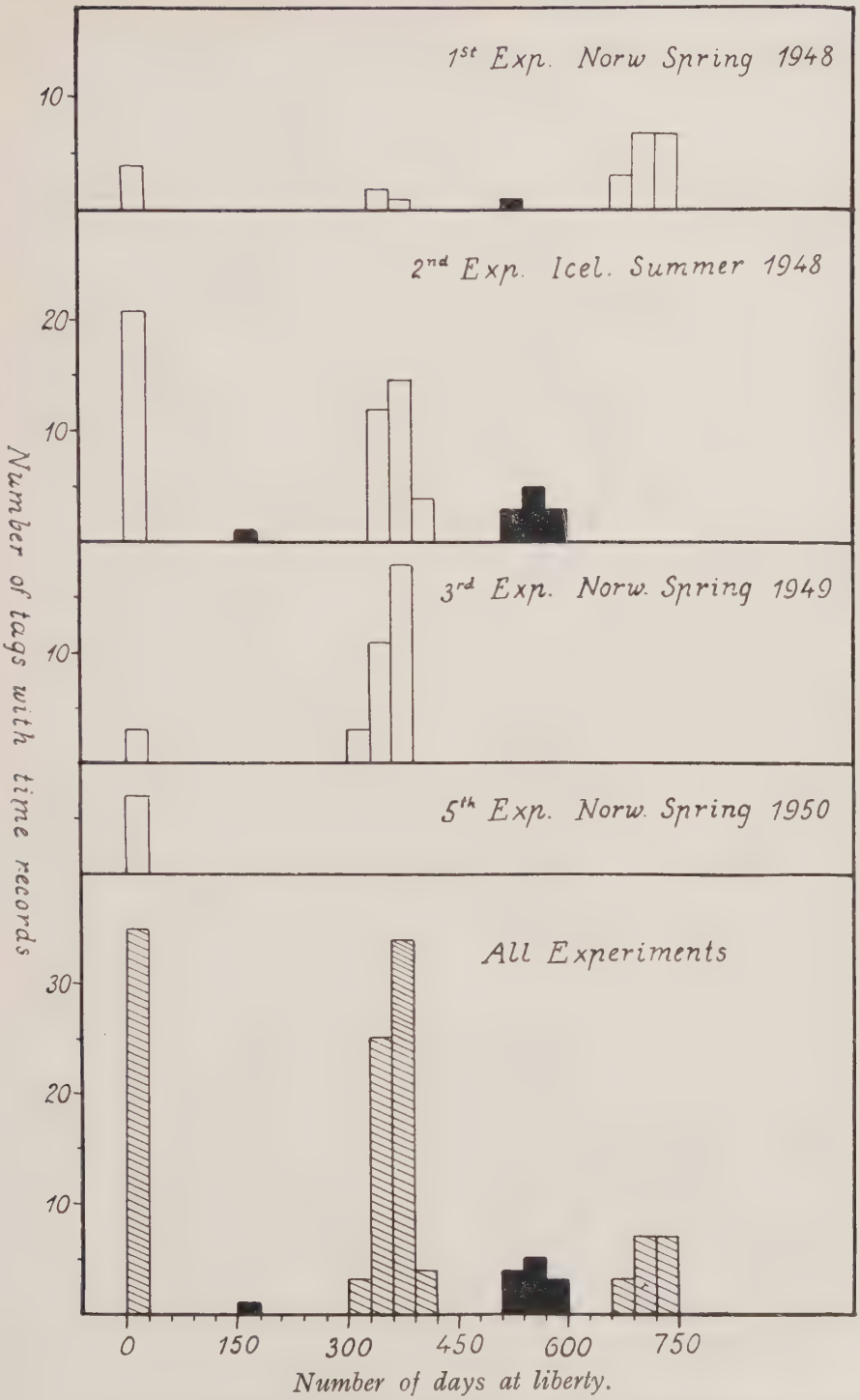

Fig. 6. Number of tags returned from the experiments plotted according to time at liberty.

August. Further it will be seen that the next return came from Norway in the spring 1949 (February). The following summer 10 returns were made in Iceland on at least six different dates and in three different localities. Finally one was caught in Norway in January 1950. For further details regarding this point the reader is referred to the records given in Appendix II, from which several other similar instances may be extracted.

Table 3. *Summary of Returns from the Different Liberations.*

Land of tagging	Local. of liberation	1948		1949		1950		
		Spring	Summer	Spring	Summer	Spring	Total	Perc. of Lib. numb.
Norway Spring 1948	A	1		1		5	7	0.69
	B	3		2	1	12	18	0.35
	Tot.	4		3	1	17	25	0.40
Iceland Summer 1948	C							0.00
	D		1		3	2	6	0.42
	E		1		5		6	0.64
	F		1		7	2	10	0.83
	G		3	1	10	1	15	1.95
	H		12		7	3	22	2.20
	I		3		15	3	21	1.40
	?				2		2	
	Tot.		21	1	49	11	82	1.20
Norway Spring 1949	J			3		32	35	0.42
Norway Spring 1950	K							0.00
	L							0.00
	M							0.00
	N							0.00
	O							0.00
Norway Spring 1950	P					7	7	0.06
Grand Totals		4	21	7	50	67	149	0.36

In Table 3 the returns from the different liberations listed in Appendix II are summarized. As mentioned earlier (page 20), the total number of returned tags is 149, or 0,36 % of the total amount marked (42,054 fish). The relatively low percentage of recaptures may at first seem suprising, but the following facts should be kept in mind: Nearly

half of the tagged herrings have been liberated during the very last season, and have consequently not yet given any considerable number of returns; the reduction plants are still partly in the process of developing their magnet equipment, and many tags have necessarily escaped detection. At the moment, the Atlanto-Scandian herring stock is certainly by far the largest one in the Atlantic, yielding more than 10.000.000 hl annually without showing any signs of depletion, therefore, the recapture percentage must be expected to be low.

From the table will be seen that the different liberations have given a varying number of returns. The percentages are given in the last column. Thus, the first experiment has given 25 returns scattered over four fishing seasons. From the second experiment carried out in seven localities, 82 returns have been made, amounting to 1,20 % of the tagged amount. However, the first liberation of this experiment might possibly be a failure as no returns have been recorded. The reason for this might be bad condition of the marked fish, as earlier mentioned on page 19. On the other hand, the highest percentages of returns originate from the last three liberations of this same experiment (locality G. H. I Fig. 5), the figures being 1,95, 2,20 and 1,40 per cent respectively. The third experiment in Norway in the spring of 1949, has given 35 returns. Finally, the two last experiments carried out this year have given only 7 returns, all of which are from the taggings in the spring herring district.

In Table 3 is also shown the number of returns from each of the five fishing seasons during which tagged herrings have been in liberation. From the first season in Norway in the spring of 1948 there are 4 returns, and from the next season at Iceland during the summer of 1948 there are 21 returns all of which originate from the taggings there the same year. During the spring season in Norway 1949, 7 tags were recorded, 3 of these originating from the first experiment the previous spring, another 3 from the third experiment (same season). The seventh record (serial no. G 3) originated from Iceland. The herring was liberated at Lundey (G Fig. 5) on August 22nd in 1948 and was recaught in the Florø—Måløy district north of Bergen, the tag being found at the A/S Stord reduction plant on the 9th of February. This is the first direct verification of migration of herring across the northern waters from Iceland to Norway. In the summer season in Iceland in 1949, 50 tags were returned all of which originated from the second experiment at Iceland in 1948, except one which had been liberated in Norway during the first experiment. The last fishing season (Norway 1950) is of particular interest. In all 67 tags were returned, 17 of these originated from the first experiment, 32 from the third and 7 from the fifth one.

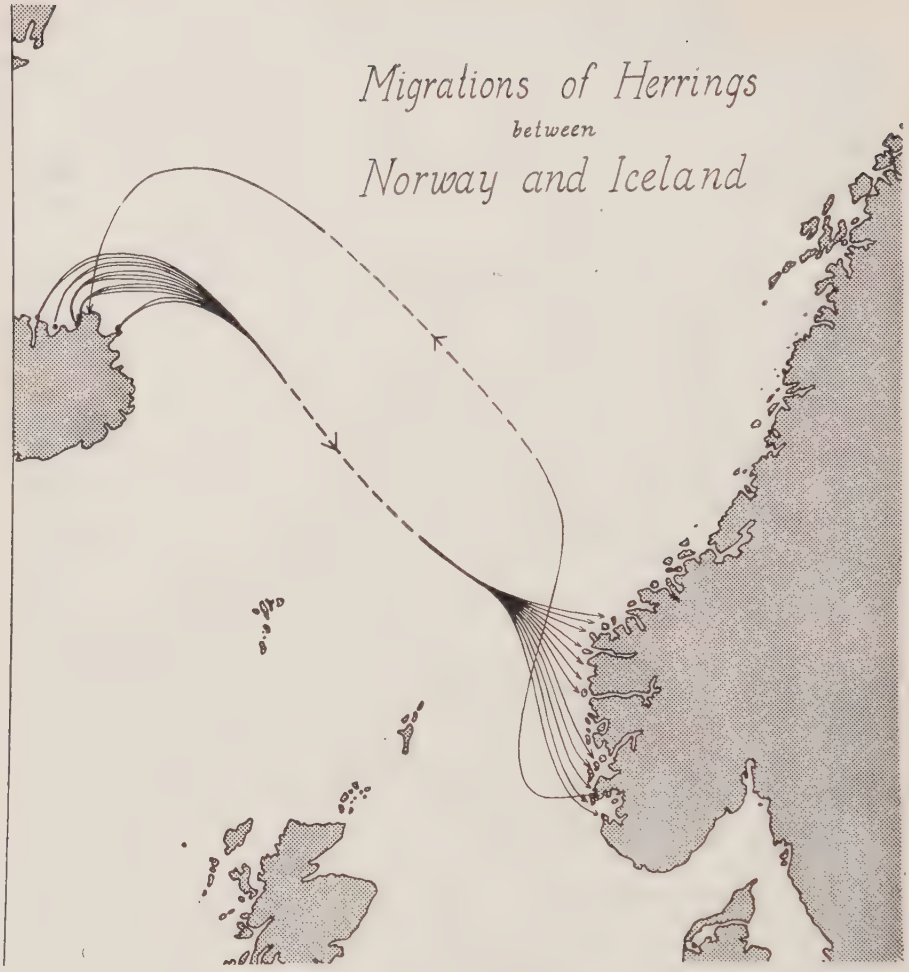

Fig. 7. The transoceanic migrations.

In this season altogether 11 returns came from the second experiment in Iceland. Whereas the first two transoceanic returns clearly indicated an intermixture between the herrings of North Iceland and Western Norway, these last year's recaptures show that the migration must take place to a considerable extent.

The most important results of the marking experiments so far, are these transoceanic migrations. In Fig. 7 an attempt has been made to illustrate the main features of these migrations as far as present knowledge permits. From the seven liberations in Iceland in 1948, returns have been made in Norway from five of the liberation localities. Referring to the map in Fig. 5 there are 2 returns made from locality D

(Skoruvikurbjarg) 2 returns from F (Gjøgur), 2 returns from G (Lundey), 3 returns from H (Leirhøfn) and 3 from I (Snarstastadanupr). From the most western locality E (Skagi) no returns have been reported except in Iceland and as already mentioned the first liberation C (Tjørnes) has not given any returns at all. As will be seen from the map (Fig. 7) the returns from Iceland are fairly well distributed all over the winter herring district. The recapture in Iceland of the herring from Norway is also shown on the map. The arrows indicate the general direction of the migrations, but no attempts have been made to indicate the exact routes.

As it has not been possible to determine the actual localities of the recaptures in Icelandic waters, one can only show in the graphic representation (Fig. 8) the number of return reported from the different landing places for the two fishing seasons 1948 and 1949. The number of returns is given and these returns are illustrated by black circles, the sizes of which correspond to the numbers. It is worth noting that by far the greatest number of the tags has been returned from the most easterly situated reduction plant, whereas no returns have been recorded from the western part of the north coast in spite of the fact that all the factories situated there are also equipped with efficient magnets.

The returns in Norway from 1948 and 1949 are so few that a graphical demonstration has not been found necessary. On the other hand the returns from 1950 are so numerous that a detailed demonstration will be of value. In Fig. 9 the distributions of the returns are demonstrated separately for herring tagged in 1948 and 1949. As the returns from Iceland have already been dealt with and there are so few returns from the tagging in 1950, both of these have been omitted. In the Figure the black dots represent the recapture localities based on information from the reduction plants. Open circles denote returns for which no recapture localities are given. These are placed on the localities of the reduction plants in which they were recovered. In some instances two possible recapture places are given. In such cases both are entered in the figure with identical symbols: upright or oblique crosses, open circles with crosses, dots or a line across. The open triangles represent the localities of tagging, which in these two years only was executed in the spring herring district. An interval between two main areas of returns will be seen. It is of particular interest to note that a great part of the returns has been recorded from the large-herring district. This really means that at least a part of the spring herring (vårsild) will later on in turn appear in the catches of the large herring (storsild). As a further indication of the relationship between the spring herring and the large herring it will be recalled that a tagged spring herring appeared in

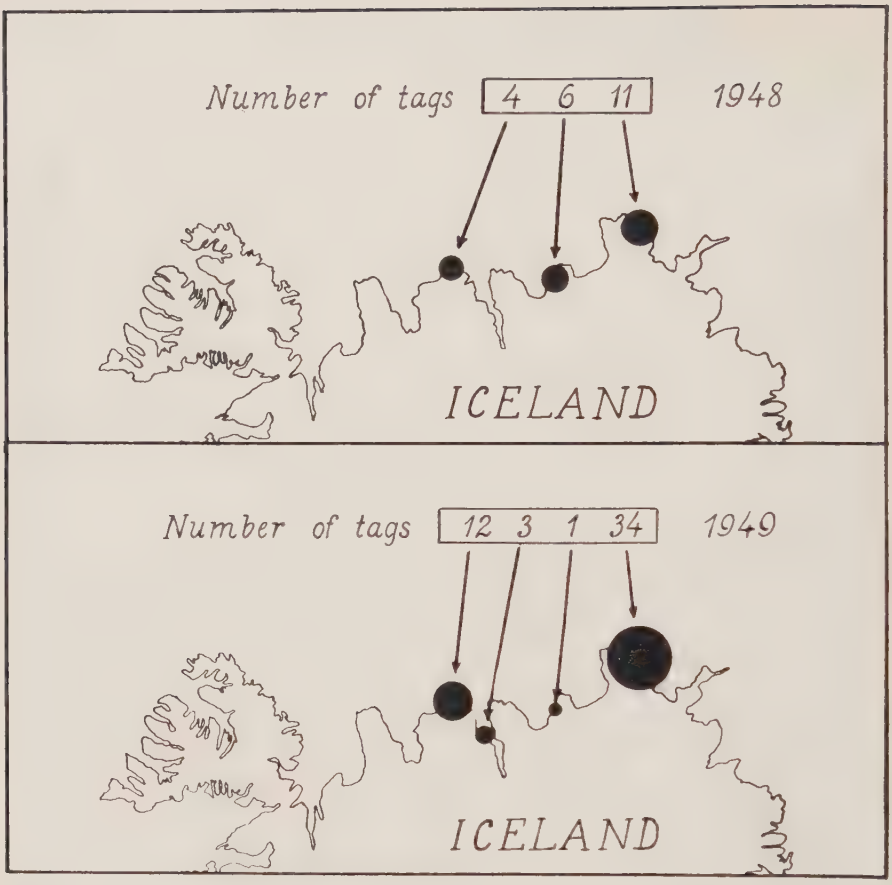

Fig. 8. The number of the returns in 1948 and 1949 from the taggings at Iceland in 1948.

the Icelandic catches and tagged herrings from the Icelandic waters were caught on the large herring grounds as well as in the spring herring district. Another striking feature will be seen when comparing the two maps on Fig. 9. Relatively more recaptures are made in the large herring district from the tagging in 1948 (ca. 50 %) than of the 1949 tagging (ca. 23 %). This may possibly indicate a gradual northwards transfer of the spawning stock according to age (Fridriksson 1944). However, further experiments and more returns are required to give any definite answer to this question.

Finally in connection with the migrations of the herring the question of the travelling speed will arise. The taggings have also furnished some observations on this point. (See also Appendix II). The following cases

Fig. 9. The distributions of the returns in Norway 1950 from the taggings on the spring herring district in 1948 and 1949.

may be mentioned: This year (1950) a tagged herring was recaught 2 days after liberation at almost the same spot, and most probably this fish has been stationary during this time interval. In contrast to this there is another example from the previous spring. A tagged herring liberated at Trosnavåg on the 9th of March at 11 a.m. was recaptured 10 n.m. from there at about 7 a.m. the 10th of March. This corresponds to a minimum speed of about ½ n. m. per hour. Information may also be gained as to the minimum average speed of the herrings on the long distance migrations. This is, for instance, the case with No. 70 in Appendix II. This fish has migrated over a distance of at least 660 n. m. in 171 days. This amount to an average speed of nearly 4 n. m. in 24 hours.[1]

[1]) Since this report was prepared 509 herrings have been tagged in the open ocean (July 1950) about 100 n. m. east of Iceland, and 1321 herrings were tagged at the north coast of Iceland (August 1950). Furthermore 11 additional tags have been returned from Icelandic reduction plants during the summer of this year.

CONCLUSION

In the preceding chapters it is demonstrated that the Norwegian—Icelandic herring tagging experiments have met with success. When properly handled the herring is capable of withstanding the shock of tagging, and this first successfully executed herring tagging experiment in European waters is certainly encouraging. Herring tagging is now being done in several European contries, with the use of different kinds of external tags and it is demonstrated that the herring also can stand up to this treatment.

It is further shown that a herring shoal must be regarded as a temporary phenomenon, for the shoals evidently disperse after a time, the fish later reforming themselves into new ones.

Another important result of the taggings is that tagged spring herrings appear in the catches in the large-herring district, and an intermixture between large and spring herring definitely takes place. If this feature continues to manifest itself, the morphological differences observed (Rasmussen 1940) (Rundstrøm 1941) need further explanation.

An outstanding feature which may be stressed as being of particular importance is that transoceanic migrations also take place to a considerable extent, this being in direct support of Fridriksson's theory, (Fridriksson 1944).

From the results already obtained through this tagging experiment it is strongly recommended that this work be continued and, if possible, extended. As the herrings in the northern waters are only caught commercially during limited fishing seasons, difficulties are encountered in the very interesting problem of fixing the routes of the migrations, but attempts will be made to find and mark herrings in the open sea in the close seasons in an attempt to clear up this special point.

Appendix I. Recordings of Liberations.

1st Experiment, Norway 1948.

Series	Number	Date	Locality of liberation	Ref. to f. 4 & 5
A 1	254	6. III	Hestvik	A
A 2	255	»	»	»
A 4	247	»	»	»
A 5	260	»	»	»
A 6	211	23. III	Breivik	B
A 8	205	»	»	»
A 9	210	»	»	»
A 10	23	»	»	»
A 10	219	11. III	»	»
B 1	260	»	»	»
B 2	178	»	»	»
B 2	82	12. III	»	»
B 3	256	»	»	»
B 4	263	»	»	»
B 5	264	17. III	»	»
B 6	150	»	»	»
B 6	106	18. III	»	»
B 7	259	»	»	»
B 8	262	»	»	»
B 9	257	»	»	»
B 10	256	19. III	»	»
C 1	260	»	»	»
C 2	100	»	»	»
C 2	149	20. III	»	»
C 3	263	»	»	»
C 4	266	»	»	»
C 5	252	22. III	»	»
C 6	251	»	»	»

2nd Experiment, Iceland 1948.

C 8	204	4. VIII	Tjørnes	C
C 9	248	»	»	»
C 10	215	»	»	»
D 3	253	8. VIII	Skoruvikur-	D
D 4	254	»	bjarg	»
D 6	246	»	»	»
D 7	252	»	»	»
D 8	254	«	»	»
E 1	153	»	»	»
E 2	240	17. VIII	Skagi	E
E 3	241	»	»	»

2nd Experiment (continued).

Series	Number	Date	Locality of liberation	Ref. to f. 4 & 5
E 4	243	17. VIII	Skagi	E
E 5	203	»	»	»
E 6	273	20. VIII	Gjøgur	F
E 7	248	»	»	»
E 8	248	»	»	»
E 9	227	»	»	»
E 10	209	»	»	»
F 1	246	27. VIII	Snartastada-	I
F 2	234	»	nupr	»
F 3	246	»	»	»
G 1	264	22. VIII	Lundey	G
G 2	262	»	»	»
G 3	243	»	»	»
G 4	220	26. VIII	Leirhøfn	H
G 5	260	»	»	»
G 6	261	»	»	»
G 7	260	»	»	»
G 8	259	27. VIII	Snartastada-	I
G 9	254	»	nupr	»
G 10	255	»	»	»

3rd Experiment, Norway 1949.

NG 1	198	28. II	Trosnavåg	J
NG 2	211	»	»	»
NG 3	246	»	»	»
NG 4	246	»	»	»
NG 5	258	»	»	»
NG 6	204	7. III	»	»
NG 7	260	2. III	»	»
NG 8	259	»	»	»
NG 9	259	3. III	»	»
NG 10	258	4. III	»	»
NI 1	255	»	»	»
NI 2	254	»	»	»
NI 3	256	5. III	»	»
NI 4	251	»	»	»
NI 5	253	»	»	»
NI 6	252	»	»	»
NI 7	258	6. III	»	»
NI 8	255	»	»	»
NI 9	246	»	»	»

Appendix I (continued).

3rd Experiment (continued).

Series	Number	Date	Locality of liberation	Ref. to f. 4 & 5
NI 10	243	6. III	Trosnavåg	J
NH 1	261	9. III	»	»
NH 2	260	»	»	»
NH 3	256	»	»	»
NH 4	258	»	»	»
NH 5	256	»	»	»
NH 6	253	»	»	»
NH 7	261	10. III	»	»
NH 8	255	»	»	»
NH 9	254	»	»	»
NH 10	251	»	»	»
NJ 1	249	»	»	»
NJ 2	37	»	»	»
NJ 3	256	»	»	»
NJ 4	178	»	»	»
NJ 6	27	»	»	»
NJ 8	7	»	»	»
NJ 10	20	»	»	»

4th Experiment, Norway 1950.

NJ 1-0	2	8. II	Torskangerpoll.	L
NJ 2-0	55	2. II	Vaulen	H
NJ 3-0	2	8. II	Torskangerpoll.	L
NJ 4-0	62	1. II	Vaulen	H
NJ 5-0	254	8. II	Torskangerpoll.	L
NJ 6-0	228	6. II	»	»
NJ 7-0	269	8. II	»	»
NJ 8-0	258	»	»	»
NJ 9-0	258	»	»	»
NJ 10-0	240	»	»	»
NK 1	243	»	»	»
NK 2	245	9. II	»	»
NK 3	251	»	»	»
NK 4	251	13. II	Fåfjorden	M
NK 5	252	»	»	»
NK 6	250	»	»	»
NK 7	251	»	»	»
NK 8	252	14. II	»	»
NK 9	258	»	»	»
NK 10	250	»	»	»
NL 1	244	8. II	Torskangerpoll.	L

4th Experiment (continued).

Series	Number	Date	Locality of liberation	Ref. to f. 4 & 5
NL 2	234	14. II	Fåfjorden	M
NL 3	252	»	»	»
NL 4	246	15. II	Vågsvågen	N
NL 5	249	16. II	»	»
NL 6	251	»	»	»
NL 7	250	15. II	»	»
NL 8	246	»	»	»
NL 9	249	16.II	»	»
NL 10	245	»	»	»
NM 1	248	»	»	»
NM 2	246	18. II	Batalden	O
NM 3	247	»	»	»
NM 4	255	»	»	»
NM 5	252	16. II	Vågsvågen	N
NM 6	250	18. II	Batalden	O
NM 7	249	19. II	»	»
NM 8	248	»	»	»
NM 9	243	»	»	»
NM 10	250	»	»	»

5th Experiment, Norway 1950.

NN 1	253	11. III	Vespestadvågen	P
NN 2	250	»	»	»
NN 3	252	»	»	»
NN 4	251	12. III	»	»
NN 5	252	»	»	»
NN 6	250	13. III	»	»
NN 7	251	»	»	»
NN 8	250	»	»	»
NN 9	252	»	»	»
NN 10	253	14. III	»	»
NO 1	224	22. III	»	»
NO 2	218	»	»	»
NO 3	209	»	»	»
NO 4	139	»	»	»
NO 5	252	10. III	»	»
NO 6	252	»	»	»
NO 7	253	»	»	»
NO 8	254	»	»	»
NO 9	251	»	Vespestadvågen	»
NO 10	263	11. III	»	»

Appendix I (continued).

5th. Experiment (continued).

Series	Number	Date	Locality of liberation	Ref. to f. 4 & 5
NP 1	249	14. III	Vespestadvågen	P
NP 2	246	»	»	»
NP 3	254	»	»	»
NP 4	250	»	»	»
NP 5	150	15. III	»	»
NP 6	244	16. III	»	»
NP 7	244	»	»	»
NP 8	250	»	»	»
NP 9	249	»	»	»
NP 10	248	17. III	»	»
NR 1	251	»	»	»
NR 2	264	18. III	»	»
NR 3	243	»	»	»
NR 4	249	19. III	Vespestadvågen	P
NR 5	247	»	»	»
NR 6	250	20. III	»	»
NR 7	252	»	»	»
NR 8	249	»	»	»
NR 9	253	»	»	»
NR 10	247	22. III	»	»
NS 1	254	»	»	»
NS 2	253	»	»	»
NS 3	237	»	»	»
NS 4	254	»	»	»
NS 5	248	»	»	»
NS 6	251	»	»	»

Appendix II. Recordings of returns.

1st. Experiment. Norway 1948.

	LIBERATED				RETURNED							Nos. of days at liberty
	Series	Date	Place	Ref. to maps p. 00	Date	Place	1948 Spring	1948 Summer	1949 Spring	1949 Summer	1950 Spring	
1	A 1	6. III	Hestvik	A	5. III	*Utsira			1			364
2	«	«	«		23. III	Fjeldberg Bruk					1	max. 747
3	A 2	«	«		?	Essen, Germany	1					?
4	«	«	«		1. III	*Egersund					1	725
5	«	«	«		9.—10. III	*Karmøy or Egersund					1	734
6	A 4	«	«		31. I	*Statthavet					1	696
7	A 5	«	«		11. III	*Ramsholmene (?)					1	735
8	A 9	9. III	Breivik	B	?	Fjeldberg Bruk	1					?
9	A 10	11. III	«		12. VIII	Raufarhøfn				1		519
10	B 6	18. III	«		5. III	*Ryfylkefjord or Karmøy			1			353
11	B 7	«	«		10. II	*Rundøfeltet					1	694
12	B 7	«	«		7. III	*Egersund					1	719
13	B 7	«	«		9. III	*Karmøy or Egersund					1	721
14	B 8	«	«		11. II	*Florødistriktet					1	695
15	B 8	«	«		10. III	*Hjeltefjorden					1	722
16	B 9	«	«		27. I	*Vallaboene					1	680
17	B 10	«	«		2. III	*Egersund					1	714
18	C 2	19.-20. III	«		ca. 11. II	*Florødistriktet					1	ca. 693
19	C 3	20. III	«		26.—27. I	*Statt					1	679
20	C 4	«	«		bf. 10. II	*Florø or Ålesund					1	max. 692

* Cases where time and place of recapture have been determined.

Appendix II *(cont.)*. Recordings of returns.

1st Experiment. Norway 1948 (cont.).

	LIBERATED				RETURNED							Nos. of days at liberty
	Series	Date	Place	Ref. to maps p. 00	Date	Place	1948 Spring	1948 Summer	1949 Spring	1949 Summer	1950 Spring	
21	C 5	22. III	Breivik	B	7. III	*Bømmelfjord			1			350
22	C 6	«	«		15. III	Stord Sildoljefabrikker					1	max. 723
23	C 6	«	«		27. I	*Goksøyrvika					1	676
24	?	?	?		?	Kopervik Sildoljefabrikker	1					?
25	?	?	?		?	« «	1					?

2nd Experiment. Iceland 1948.

26	D 3	6. VIII	Skoruvikurbjarg	D	Ult. VIII	Siglufjord		1				max. 25
27	D 3	»	»		1. IX	Raufarhøfn				1		max. 391
28	D 3	»	»		9. IX	»				1		max. 399
29	D 4	»	»		29. I	*Goksøyrvika					1	541
30	D 6	»	»		8. IX	Raufarhøfn				1		max. 398
31	D 6	»	»		3. II	*Florø					1	546
32	E 2	16. VIII	Skagi	E	4. IX	Raufarhøfn		1				max. 19
33	E 2	»	»		14. IX	»				1		max. 394
34	E 3	»	»		4. VIII	»				1		max. 353
35	E 3	«	»		7. IX	»				1		max. 387
36	E 4	»	»		?	Siglufjord				1		?
37	E 4	»	»		7. IX	Raufarhøfn				1		max. 387

Appendix II *(cont.)*. Recordings of returns.

2nd Experiment. Iceland 1948 (cont.).

	LIBERATED				RETURNED							Nos. of days at liberty
							1948		1949		1950	
	Series	Date	Place	Ref. to maps p. 00	Date	Place	Spring	Summer	Spring	Summer	Spring	
38	E 6	20. VIII	Gjøgur	F	?	Siglufjord				1		?
39	E 7	»	»		15. VIII	Raufarhøfn				1		max. 360
40	E 7	»	»		20. VIII	»				1		max. 365
41	E 7	»	»		13. IX	»				1		max. 389
42	E 7	»	»		?	Hjalteyri				1		?
43	E 7	»	»		9. III	Fjellberg Bruk					1	max. 566
44	E 8	»	»		Ult. VIII	Siglufjord		1				max. 12
45	E 10	»	»		27. VIII	Raufarhøfn				1		max. 372
46	E 10	»	»		?	Siglufjord				1		?
47	E 10	»	«		23. II	*Sletta or Sognesjø					1	552
48	F 1	27. VIII	Snartastadanupr	H	?	Siglufjord				1		?
49	F 1	»	»		16. VIII	Raufarhøfn				1		max. 354
50	F 1	»	»		30. III	Storesund Salteri					1	max. 580
51	F 2	»	»		?	Siglufjord				1		?
52	F 2	»	»		15. VIII	Raufarhøfn				1		max. 353
53	F 2	»	»		16. VIII	»				1		max. 354
54	F 2	»	»		2. IX	»				1		max. 371
55	F 2	»	»		28. III	*Sunnhordland or Måløydistriktet					1	577
56	F 2	»	»		31. I	*Florødistriktet					1	522
57	F 3	»	»		?	Siglufjord				1		?
58	F 3	»	»		17. VIII	Raufarhøfn				1		max. 355

Appendix II *(cont.)*. Recordings of returns.

2nd Experiment (cont.). Iceland 1948.

LIBERATED					RETURNED							Nos. of days at liberty
	Series	Date	Place	Ref. to maps p. 00	Date	Place	1948 Spring	1948 Summer	1949 Spring	1949 Summer	1950 Spring	
59	G 1	21. VIII	Lundey	G	15. VIII	Raufarhøfn				1		max. 359
60	G 1	»	»		»	»				1		max. 359
61	G 1	»	»		16. VIII	»				1		max. 360
62	G 1	»	»		17. VIII	»				1		max. 361
63	G 1	»	»		8. IX	»				1		max. 383
64	G 2	22. VIII	»		30. VIII	»		1				max. 8
65	G 2	»	»		Ult. VIII	Siglufjord		1				max. 9
66	G 2	»	»		28. VIII	Raufarhøfn				1		max. 371
67	G 2	»	»		?	Hjalteyri				1		?
68	G 2	»	»		?	Siglufjord				1		?
69	G 3	»	»		4. IX	Raufarhøfn		1				max. 13
70	G 3	»	»		9. II	*Florø—Måløy			1			171
71	G 3	»	»		?	Siglufjord				1		?
72	G 3	»	»		?	»				1		?
73	G 3	»	»		26. I	*Statt					1	522
74	G 4	26. VIII	Leirhøfn	I	3. IX	Raufarhøfn		1				max. 8
75	G 4	»	»		5. IX	»		1				max. 10
76	G 4	»	»		8. IX	»		1				max. 13
77	G 4	»	«		27. III	*Haugesund (?)					1	578
78	G 5	»	»		30. VIII	Raufarhøfn		1				max. 4
79	G 5	»	»		7. IX	Husavik		1				max. 12
80	G 5	»	»		?	»		1				?

Appendix II (*cont.*). Recordings of returns.

2nd Experiment (cont.). Iceland 1948.

LIBERATED					RETURNED							Nos. of days at liberty
	Series	Date	Place	Ref. to maps p. 00	Date	Place	1948 Spring	1948 Summer	1949 Spring	1949 Summer	1950 Spring	
81	G 5	26. VIII	Leirhøfn	I	27. I	*Svinøyhavet					1	519
82	G 6	»	»		7. IX	Raufarhøfn		1				max. 12
83	G 6	»	»		15. VIII	»				1		max. 352
84	G 6	»	»		29. VIII	»				1		max. 368
85	G 6	»	»		30. VIII	»				1		max. 369
86	G 6	»	»		?	Hjalteyri				1		?
87	G 6	»	»		18. II	Stord Sildoljef.					1	max. 541
88	G 7	»	»		Ult. VIII	Siglufjord		1				max. 5
89	G 7	»	»		4. IX	Husavik		1				max. 9
90	G 7	»	»		«	»		1				max. 9
91	G 7	»	»		»	»		1				max. 9
92	G 7	»	»		»	»		1				max. 9
93	G 7	»	»		19. VIII	Raufarhøfn				1		max. 358
94	G 7	»	»		28. VIII	«				1		max. 367
95	G 7	»	»		1. IX	«				1		max. 371
96	G 8	26. VIII	Snartastadanupr	H	3. IX	«		1				max. 8
97	G 8	»	»		8. IX	«		1				max. 13
98	G 8	»	»		12. VIII	«				1		max. 351
99	G 8	»	»		1. IX	«				1		max. 371
100	G 8	»	»		?	Siglufjord				1		?
101	G 9	27. VIII	»		13. IX	Raufarhøfn				1		max. 382

Appendix II (*cont.*). Recordings of returns.

2nd Experiment (cont.). Iceland 1948.

LIBERATED					RETURNED							Nos. of days at liberty
	Series	Date	Place	Ref. to maps p. 00	Date	Place	1948 Spring	1948 Summer	1949 Spring	1949 Summer	1950 Spring	
102	G 10	27. VIII	Snartastadanupr	H	3. IX	«		1				max 7
103	G 10	»	»		27. VIII	«				1		max. 365
104	G 10	»	»		13. IX	«				1		max. 382
105	G 10	»	»		?	Siglufjord				1		?
106	?	?	?		?	«				1		?
107	?	?	?		?	Husavik				1		?

3rd. Experiment, Norway 1949.

108	NG 2	28. II	Trosnavåg	J	21. II	*Rundøfeltet					1	358
109	NG 4	»	»		bf. 15. II	Florødistriktet (?)					1	max. 353
110	NG 5	»	»		2. III	*Egersund					1	367
111	NG 8	2. III	»		bf. 31. I	Ålesunddistriktet					1	max. 335
112	NG 8	»	»		5. III	*Ryfylke or Karmøy			1			3
113	NG 9	3. III	»		14. III	Karmøens Sildoljefabrikk			1			max. 11
114	NG 9	»	»		bf. 8. III	*Røvær (?)					1	max. 370
115	NG 9	»	»		20. III	Fjeldberg Bruk					1	max. 382
116	NG 10	4. III	»		ca. 8. III	*Florø or Haugesund					1	ca. 369
117	NH 2	9. III	»		28. II	*Moster					1	356
118	NH 3	»	»		ca. 8. II	*Måløydistriktet					1	ca. 336
119	NH 3	»	»		10. III	Fjeldberg Bruk					1	max. 366

Appendix II (*cont.*). Recordings of returns.

2nd Experiment (*cont.*). *Iceland 1948.*

	LIBERATED				RETURNED							Nos. of days at liberty
	Series	Date	Place	Ref. to maps p. 00	Date	Place	1948		1949		1950	
							Spring	Summer	Spring	Summer	Spring	
120	NH 3	9. III	Trosnavåg	J	10. III	*Kavholmen			1			1
121	NH 4	»	»		3. III	*Urter					1	359
122	NH 5	»	»		ca. 1. III	*Sletta					1	ca. 357
123	NH 5	»	»		2. II	*Bremanger					1	330
124	NH 6	»	»		2. III	*Egersund or Karmøy					1	358
125	NH 7	10. III	»		ca. 2. III	*Egersund					1	ca. 357
126	NH 7	»	»		6. III	Stord Sildoljef.					1	max. 361
127	NH 7	»	»		18. III	*Sunnhordland or Måløy					1	373
128	NH 8	»	»		5. III	*Sletta					1	360
129	NH 8	»	»		10. III	*Ferkingstadøyene					1	365
130	NH 10	»	»		26-27. I	*Statt					1	323
131	NH 10	»	»		ca. 28. II	*Sve -Rovær (?)					1	ca. 355
132	NH 10	»	»		4. IV	Storesund Salteri					1	390
133	NI 2	4. III	»		2. -3. III	*Sletta					1	364
134	NI 2	»	»		ca. 9. III	*Haugesunddistriktet					1	ca. 370
135	NI 3	5. III	»		10. III	*Ramsholmene					1	370
136	NI 5	»	»		2. III	*Egersund or Skudenes					1	362
137	NI 5	»	»		27. I	*Svinøyfeltet					1	328
138	NI 8	6. III	»		bf. 15. III	*Sunnhordland or Måløy					1	max. 375
139	NI 8	»	»		6. III	Stord Sildoljefabrik					1	max. 365
140	NI 10	»	»		7. III	*Ramsholmene					1	366

Appendix II (*cont.*). Recordings of returns.

3rd Experiment, Norway 1949.

LIBERATED					RETURNED								Nos. of days at liberty
	Series	Date	Place	Ref. to maps p. 00	Date	Place	1948		1949		1950	
							Spring	Summer	Spring	Summer	Spring	
141	NJ 1	10. III	Trosnavåg	J	20. III	Haugesund Sildoljef.					1	max. 375
142	NJ 4	«	»		7. III	*Løsgrunnen, Egersund					1	362

4th Experiment, Norway 1950.

						NO RETURNS						

5th Experiment, Norway 1950.

143	NN 3	11. III	Vesbestadvågen	P	21. III	Ronglan Sildoljef.					1	max. 10
144	NO 8	10. III	»		28. III	Lorentz Nilssen A/S					1	max. 18
145	NO 8	»	»		10. III	*Karmøy or Egersund					1	0
146	NO 9	»	»		10. III	* »					1	0
147	NP 4	14. III	»		18. IV	Stord Sildoljef.					1	max. 4
148	NP 7	16. III	»		18. III	*Vespestadvågen					1	2
149	NR 7	20. III	»		31. III	Stord Sildoljef.					1	max. 11

LITERATURE

1. *Fridriksson, 'Arni:* »Nordurlands-Síldin« (The Herring of the North Coast of Iceland). Atvinnudeild Háskólans, Rit Fiskideildar 1944, Nr. 1.
Siglufirdi 1944.

2. *Fulton, T. Wemyss:* »An Experimental Investigation on the Migrations and Rate of Growth of Food Fishes«.
11th. Annual Report of the Fishery Board for Scotland.
Edinburg 1893.

3. *Rasmussen, Thorolv:* »To stammer innenfor den norske vintersild«.
Fiskeridirektoratets Skrifter, Vol. VI. No 4.
Bergen 1940.

4. *Rounsefell, George A.* and *Dahlgren, Edwin H.:* »Tagging Experiments on the Pacific Herring, Clupea pallasii«.
Journal du Conseil, Vol. VIII. No 3.
Copenhagen 1933.

5. *Runnstrøm, Sven:* »Racial Analysis of the Herring in Norwegian Waters«.
Fiskeridirektoratets Skrifter, Vol. VI. Nr. 7.
Bergen 1941.

Vol. V.

Nr. 1. *Thor Iversen:* Sydøstgrønland Jan Mayen. Fiskeriundersøkelser. 1936.
» 2. *Sven Runnström:* A Study on the Life History and Migrations of the Norwegian Spring-Herring based on the Analysis of the Winter Rings and Summer Zones of the Scale. 1936.
» 3. *Erling Sivertsen:* Torskens gytning. Undersøkelser 1934—35. 1937.
» 4. *Johan Hjort* og *Johan T. Ruud:* Rekefisket som naturhistorie og samfundssak. 1938.
» 5. *Gulbrand Lunde* og *Sigurd Lunde:* Undersøkelser over forekomsten av carrageen. 1938.
» 6. *Finn Devold:* The North Atlantic Halibut and Net Fishing. 1938.
» 7. Torsken og fiskehavet 1937. The Cod and the Sea 1937. 1938.
1) *Oscar Sund:* Merking av torsk (Cod tagging experiments).
2) *Oscar Sund:* Torskebestanden i 1937 (the stock of Cod 1937).
3) *Gunnar Rollefsen:* Aldersundersøkelser (Age analysis of the 1937 catch of Cod).
4) *Jens Eggvin:* Trekk av Nord-Norges oceanografi sett i sammenheng med torskefisket (Oceanographical conditions in North-Norway connected with the cod fisheries).
5) *O. S.:* Summary in English 1—4.
» 8. *Erling Sivertsen:* Undersøkelser over forholdet mellem spiss- og bredhodet ål og deres næring. 1938.

Vol. VI.

Nr. 1. Fisken og havet. (Fra fiskeriundersøkelsene i 1938). 1939.
Oscar Sund: Torskebestanden i 1938.
Gunnar Rollefsen: Skreiens alder.
Jens Eggvin: Oceanografisk beretning.
Jens Eggvin: Bunntemperaturen langs Norges kyst og i den nordlige del av Nordsjøen.
Oscar Sund: Sildeundersøkelsene i 1938.
Th. Rasmussen: Fluktuasjoner i vintersildens utvikling og gytning.
P. Soleim: Rauåten og sildelarvene i den nordøstlige Nordsjø i april 1937.
Finn Devold: Kveiteundersøkelsene i 1938.
Paul Bjerkan: Brislingundersøkelser i 1938.
» 2. *Johan T. Ruud:* Torsken i Oslofjorden. 1939.
» 3. *Alf Dannevig:* The Propagation of the Common Food Fishes on the Norwegian Skager Rack Coast. With Notes on the Hydrography. 1940.
» 4. Fisken og havet. (Fra fiskeriundersøkelsene i 1939). 1940.
Sildeundersøkelser i 1939:
1. *Oscar Sund:* Sildens alder og størrelse i 1939.
2. *Oscar Sund:* Undersøkelser på sjøen.
Th. Rasmussen: Islandssild i norske kystfarvann.
Th. Rasmussen: To raser innenfor den norske vintersild.
P. Soleim: Sildelarvene på vårsildfeltet.
P. Soleim: Storsildas og vårsildas gytefelter.
Gunnar Rollefsen: Skreibestanden i 1939.
Paul Bjerkan: Brislingsundersøkelser i 1939.
» 5. *Jens Eggvin:* The Movements of a Cold Water Front. Temperature Variations along the Norwegian Coast based on Surface Thermograph Records. 1940.
» 6. *Thor Iversen:* Ishavsøya Hopen. 1941.
» 7. *Sven Runnström:* Racial Aanalysis of the Herring in Norwegian Waters. 1941.
» 8. *Sven Runnström:* Quantitative Investigations on Herring Spawning and its Yearly Fluctuations at the West Coast of Norway. 1941.

1942.

Vol. VII.

Nr. 1. Fisken og havet. (Fra fiskeriundersøkelsene i 1940). 1942.
Oscar Sund: Sildeundersøkelser i 1940.
1. Sildas alder og størrelse i 1940.
2. Undersøkelser på sjøen.
3. Andre undersøkelser.
Gunnar Rollefsen: Litt om skreiens dødelighet.
Gunnar Rollefsen: Skreibestanden 1940.
Jens Eggvin: Den store utskiftning av vannmassene langs norskekysten i 1940.
Paul Bjerkan: Brislingundersøkelser i 1940.
Thorolv Rasmussen: Borgepollsilda.

Nr. 2. *Peder A. Soleim:* Årsaker til rike og fattige årganger av sild. 1942.
» 3. *Finn Devold:* Contributions to the Plaice Investigations in Norwegian Waters. 1942.
» 4. *Birger Rasmussen:* Om dypvannsreken ved Spitsbergen. 1942.
» 5. *Peder Ottestad:* On Periodical Variations in the Yield of the Great Sea Fishe-
» 6. Fisken og havet. (Fra fiskeriundersøkelsene i 1941). 1944.
ries and the Possibility of establishing Yiel Prognoses. 1942.
Oscar Sund: Sildeundersøkelser i 1941.
1. Undersøkelse av sildprøver.
2. Undersøkelser på sjøen.
Gunnar Rollefsen: Skreiens fornyelse.
Paul Bjerkan: Brislingundersøkelser i 1941.
Jens Eggvin: Den oseanografiske situasjon i det norske kysthav 1941 og femårs middeltemperaturer i overflatelaget og ved bunnen.
Jens Eggvin: Oseanografisk beretning.
» 7. *Kristian Fredrik Wiborg:* The Production of Zooplankton in a Landlocked Fjord. The Nordåsvatn near Bergen in 1941—42. 1944.
» 8. *Bjørn Vindenes:* On the Tidal Waters in the Nordåsvatn. A Homemade, Self-recording Tide-Gauge. 1944.
» 9. *Jens Eggvin* and *Finn Spinnangr:* Fog Forecasting and Sea-Surface Tem-
» 10. Fisken og havet. (Fra fiskeriundersøkelsene i 1942). 1945.
perature. 1944.
Oscar Sund: Sildundersøkelser i 1942.
Paul Bjerkan: Brislingundersøkelser i 1942.

Vol. VIII.

Nr. 1. *P. A. Soleim:* A Contribution to the Knowledge of the Lesser Sandeel (Ammodytes Lancea) in North European Waters. 1945.
» 2. *Birger Rasmussen:* Trekk fra dypvannsrekens biologi i norske kystfarvann. I. Vigrafjorden, Møre. 1945.
» 3. Oppdrett av østersyngel. Forsøk utført ved Statens Utklekningsanstalt ved Flødevigen 1933—1943. 1945.
» 4. *Alf Dannevig:* Undersøkelser i Oslofjorden 1936—1940. Egg og yngel av vårgytende fiskearter. 1945.
» 5. *Kristian Fredrik Wiborg:* Undersøkelser over oskjellet (Modiola modiolus (L.)). I. Alminnelig biologi, vekst og økonomisk betydning. 1946.
» 6. Ragnv. Løversen: Torskens vekst og vandringer på Sørlandet. Belyst ved merkingsforsøk 1937—1943. 1946.
» 7. *Eilert Theisen:* Tanafjorden. En finnmarksfjords oseanografi. 1946.
» 8. *Ragnv. Løversen:* Undersøkelser i Oslofjorden 1936—1940.
Fiskeyngelens forekomst i strandregionen. 1946.
» 9. *Eilert Theisen:* Correction of Temperatures and a Handy Way of Making Correction Charts for Reversing Thermometers. 1947.
» 10. *Elisabeth Pedersen:* Østersens respirasjon. Undersøkelser utført ved Statens Utklekningsanstalt Flødevigen. 1947.

Vol. IX.

Nr. 1. *Elisabeth Pedersen:* Bestemmelse av kalsium i sjøvann.
Undersøkelser utført ved Statens Utklekningsanstalt Flødevigen. 1947.
» 2. *K. F. Wiborg:* Experiments with the Clarke-Bumpus Plankton Sampler and with a Plankton Pump in the Lofoten Area in Northern Norway. 1948.
» 3. *K. F. Wiborg:* Investigations on Cod Larvae in the Coastal Waters of Northern Norway. Occurrence of cod larvae, and occurrence of food organisms in the stomach contents and in the sea. Preliminary report. 1948.
» 4. *K. F. Wiborg:* Some Observations on the Food of Cod (Gadus callarias L.) of the 0—II-group from Deep Water and the Littoral Zone in Northern Norway and from Deep Water at Spitsbergen. 1948.
» 5. *G. Dannevig:* The Biology of Salmon from Southern Norway. 1949.
» 6. *Alf Dannevig:* The Variation in Growth of young Codfishes from the Norwegian Skager Rack Coast. — Cod Scales as Indicator of Local Stocks.
« 7. Thorolv Rasmussen: Is the Icelandic «Nordurlandssild» identical with the Norwegian Winter Herring. 1950.
« 8. K. F. Wiborg: The Food of Cod (Gadus callarias L.) of the O-II-Group from deep Water in some Fjords of Northern Norway. With one Appendix: Oothrix borealis n.sp., a bottom-dwelling Copepod from Northerrn Norway. 1949.
« 9. Alf Dannevig: The Influence of the Environment on Number of Vertebrae in Plaice. 1950.